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The Integrator

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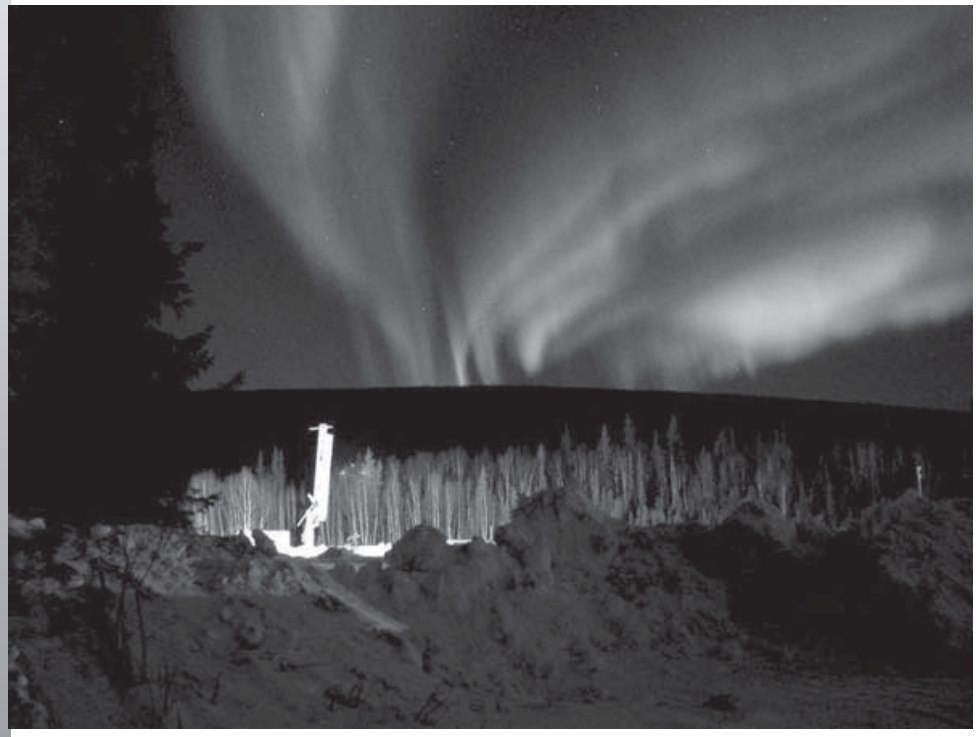
Features

Code 450 Mission Services Program

NASA Provides Suborbital Support to Diverse Customer Community



NASA's Ground Network (GN) Project (GSFC Code 453) provides Tracking, Data, Acquisition, and Communications (TDAC) services to a wide variety of suborbital customers. Pictured here is a scientific sounding rocket about to be launched from Poker Flat, Alaska. The GN Project supported this rocket (along with six others in the campaign) as it explored a remarkable phenomena—Earth's aurora—strikingly visible in the photo above.

To learn more about the GN Project and the services it provides, turn to page 27.

In This Issue ...

A Message from the Associate Director / Program Manager for Mission Services

There are many exciting activities and events to report in this issue of *The Integrator*! We have achieved very significant milestones in recent months, and members of the MSP team are working on such diverse things as helping to locate a "lost" spacecraft (IMP-8), providing support to our military during weapons systems testing, preparing for the launches of the A-Train constellation spacecraft, and more.

In May, NASA accepted TDRS-J from Boeing Satellite Systems (BSS), and contractors at the White Sands Complex (WSC) in New Mexico have assumed responsibility for operations and maintenance of the spacecraft, which is now called TDRS-10. TDRS-I, which NASA accepted in early July, has also been turned over to the WSC contractor team to operate and maintain. My hat is off to the team responsible for recovery of TDRS-I (now called TDRS-9) from its non-nominal orbit. They completed a thorough test and evaluation of the TDRS-I spacecraft, enabling its acceptance. These major milestones represent the culmination of over ten years of work for the TDRS H, I, J Project team, and mark the beginning of the new spacecraft's contributions to the NASA mission through service to the Space Network (SN) customer community. Congratulations to the entire TDRS and SN team!

In addition, we are currently evaluating responses to Requests For Proposals (RFPs) for both the Near Earth Networks Services (NENS) and the Mission Operations and Missions Services (MOMS) contracts. These efforts will provide follow-on contracts to NASA's Consolidated Space Operations Contract, which will expire at the end of this calendar year. I would like to express my appreciation to the procurement development teams who put together these RFPs. They assembled two remarkably complex packages, meeting every schedule milestone on a very tight schedule!

We also continue to plan for the future here in the MSP. Recently, Dennis Vander Tuig and I participated in the Code 400 strategic planning retreat held this past spring. At this off-site forum, managers from the Flight Programs and Projects Directorate discussed the future direction of NASA's space program, the needs of our customers, and solutions to the challenges that await us. By working across programs and the Directorate, we are finding ways to optimally resolve these challenges.

I would like to welcome a new team to the MSP whose members are striving to demonstrate technologies critical to NASA's future. The Mars Optical Communications Demonstration team successfully completed a conceptual study phase this May, and we are currently creating a related formulation project. Rick Fitzgerald has joined the MSP management team as the Mars Laser Communications Demonstration (LCD) Project Formulation Manager. The LCD Project team's efforts will open the door to the future for NASA's near Earth and deep space missions by enabling dramatic improvements in communications bandwidth for spacecraft. This effort is considered so important to NASA that it is specifically identified on page three of our new strategic plan. Please welcome Rick and his team to the Program and fully support them in this challenging endeavor!

As we continue to prepare for the future, I would like to remind our staff of the critical importance we place on maintaining and improving our highly trained workforce. While there has been an increase in MSP staff members taking advantage of training opportunities, we need to challenge ourselves to do even better. There are numerous technical and management classes available at GSFC and elsewhere; I encourage all of you to make the most of these educational resources. With an expert workforce educated in the latest concepts and methods, we can provide the leadership necessary to enable the excellent communications, tracking and navigation capabilities our customers require today and in the years to come.

Phil Liebrecht

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CODE 450

Mission Services Program

Rick Fitzgerald Named Formulation Manager for the Mars Laser Communications Demonstration Project

The Mars Laser Communications (Lasercom) Demonstration (LCD) Project continues to move forward with the naming of Rick Fitzgerald as the Formulation Manager. As stated in a previous article (see the March 2003 issue of *The Integrator*), Lasercom may be the wave of the future for deep space satellite communications because it can enable the transmission of large volumes of scientific data over the vast distances of our solar system.

Since the last article, MIT Lincoln Laboratory (MIT/LL) has completed Phase II of the Mars Lasercom Feasibility Study, and the Project has submitted a Program Operating Plan (POP) to Code S for FY04-FY09. GSFC has also asked MIT/LL to team with Code 450 to provide Lasercom Systems Engineering for the Project and to supply the Mars Lasercom terminal itself. Stated goals for the terminal include a communication rate of 10 Mbits/second when Mars is at maximum range (which leads naturally to a rate of about 250 Mbits/second when Mars is at minimum range) and the ability to operate very close to the sun. The demonstration terminal is scheduled for launch on the Mars Telesat Orbiter some time around October 2009. The team is currently planning for a Concept Review in October at GSFC.

Before assuming the LCD Project management role, Rick Fitzgerald was the Mission Manager for the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) Mission. Sam Zingales from JPL is the Lasercom Deputy Project Manager. Bernard Edwards, Chief Engineer for the Microwave and Communication Systems Branch, is currently providing systems engineering support and acting as the Flight Segment Manager. Dr. Ted Benjamin of ITT is supporting the team with his satellite communications experience. In addition, the Optical Communications Section at JPL provides technical support for the project.

For additional information, please contact the LCD Project Formulation Manager via email (Richard.J.Fitzgerald@nasa.gov) or telephone (301-286-6310).

Goddard Team Helps Establish NASA Technical Standards

GSFC personnel are active members of the Consultative Committee for Space Data Systems (CCSDS), an international organization whose members work to provide optimized solutions (called CCSDS Recommendations) for space mission data handling needs. GSFC personnel participated in numerous national and international standards forums this spring, including the NASA Technical Standards Working Group at NASA HQ in March 2003 and the CCSDS Spring meetings in Holland and Italy in April 2003. The following summarizes the activities of the various CCSDS subgroups in which GSFC personnel participate.

Channel Coding/Modulation:
The group finished two papers for submission to the Earth Science Technology Office for their annual conference in late June. Both papers consist of CCSDS recommendations proposed for flight ASICs. We are working with the GPM

(continued on page 6)

(continued from page 5)

project to produce a test for the LDPC codes. In addition, we presented a design review for our High Rate Baseband Multi-modulator prototype board and will submit the board for fabrication shortly. [Technical Representative Wai Fong/GSFC Code 564]

Cross Support Operations: The CCSDS is developing a standard for the interface through which space flight mission managers request tracking, telemetry, and command (TT&C) and Space Link Extension (SLE) services from ground stations and networks. The standard is intended for use, not just by the space flight projects and networks operated by the CCSDS member agencies (such as NASA), but also by commercial networks and networks operated by other government agencies. This standard is written in the eXtensible Markup Language (XML). As part of the process of developing the standard, prototypes are under development for testing by Goddard's Wallops Flight Facility, JPL's Deep Space Network, and the U.S. Air Force Satellite Control Network. These prototypes are currently being modified to conform to the draft version 0.1.0 of the SLE Service Management Service Request XML schema specification, with the target of Fall 2003 for interoperability testing among the prototypes. [Technical contact: Tim Ray/GSFC Code 586]

Information Interchange Standards: Using EAST (Extended ADA SubseT) tools provided by Centre National d'Etudes Spatiales (CNES) colleagues, members created and modified a formal description of a data set's format that involved CDC-3000 series 48-bit floating point values, integers, and bit fields. EAST-related tools convert several files of this data into a new format using IEEE 64-bit real numbers and integers in preparation for a demonstration for the National Space Science Data Center (NSSDC). They may use this technology to update the information representations of old data sets to make the data more accessible to modern computer platforms. [Technical Representative Donald Sawyer/GSFC Code 633]

Navigation: With support from the Information Interchange team, we are working on updates to the CCSDS Orbit Data Messages document to separate semantics and syntax as a step toward creating a Extensible Markup Language (XML) compliant standard. Next, the document will be distributed for another CCSDS-wide review. We collected comments from flight dynamics personnel regarding a description of operational characteristics for tracking data support and will use this information as initial material for a future tracking data standard. [Technical Representative Felipe Flores-Amaya/GSFC Code 595]

Protocols/Advanced Orbiting Systems: Attended a James Webb Space Telescope (JWST) telecon to discuss various end-to-end data system designs to keep the CCSDS File Delivery Protocol (CFDP) in the design (despite the extremely high downlink rate of 100 megabits per second). Completed a port for CCSDS Telecommand software to the Linux operating system. The port was hooked up to the Space Technology-5 mission's on-board command system and it worked well. The Global Precipitation Measurement mission plans to integrate CFDP implementation into their flight software. [Technical Representative Tim Ray/GSFC Code 584]

Spacecraft Onboard Interfaces (SOIF): We are supporting system level concept definition for a test bed to support SOIF concepts. The prime focus of this effort is a flight Ethernet-based spacecraft using Internet Protocol. Specific activities include the development of an overall concept for the test bed and the development of a presentation on IP in space. A prototype network bus manager has been integrated and is operating with a spacecraft ground system (ITOS, a.k.a. the Integrated Test and Operating System). On the hardware front we have been supporting a Glenn Research Center technology activity to develop a SpaceWire interface chip that will allow missions to utilize onboard networking concepts at data rates from 1 to 500 megabits per second in a standard way. We are providing input to ensure the chip can support a SOIF networked environment. This effort included the development of a simulation of a possible transport layer. Work is proceeding on the definition of security requirements and a spacecraft network addressing scheme for operational missions needs. [Technical Representative Richard G. Schnurr/GSFC Code 560]

For further information, please contact Felipe Flores-Amaya, GSFC Data Standards Manager, at 301 286-9068, or visit the CCSDS web pages (http://www.ccsds.org).

Mission Services Program Welcomes Sonia Rivera Oquendo

The Mission Services Program is pleased to add Sonia Rivera Oquendo to its ranks for the summer. Sonia comes to us from the University of Puerto Rico, Mayaguez Campus. Sonia is a fourth year accounting major, applying her skills in support of the Mars Laser Communications Formulation Project. She is getting a good taste of work life at GSFC while meeting and getting to know the great folks in Mission Services. An interesting thing that she has already found is that people are very impressed that Puerto Rican interns are bilingual, having grown up speaking Spanish and English. Most of us wish we had the same opportunity to learn a second language when we were growing up.

Sonia plans to graduate in May 2004 and take the CPA exam next summer. She is not yet sure just where she wants to land for her career in accounting but loves doing taxes! This summer, she is exploring whether she might like to come to GSFC in the future. At home in Puerto Rico and when she is not in class, Sonia can be found at the beach scuba diving and enjoying the sun and water. She also enjoys many outlets for her love of music by dancing and singing at local churches in her spare time.

Sonia comes to us under the auspices of the GSFC Equal Opportunity Summer Internship Program. The handbook tells us, 'Interns work in areas that contribute directly to the mission of NASA's GSFC. In return, past participants have gained practical research experience and professional career development information, as well as a network of resources that will be invaluable throughout their academic and professional careers. The program is intended to encourage high-caliber college students to both pursue and earn graduate degrees and to enhance their interest in careers at GSFC by exposing them to its professional resources and facilities.'

Stop by and say hello to Sonia in Bldg. 12, Room E232.

By Rosemary Bruner/GSFC Code 450

Sonia Rivera Oquendo,
the Mission Services Program's new summer intern

*Check out the **Mission Services Milestone Chart** in the center of this issue for current MSP activities.*

Further updates will be provided in future issues of The Integrator.

Source Evaluation Board Examines Follow-on Proposals

Proposals for two follow-on contracts to NASA's Consolidated Space Operations Contract (CSOC) are currently being evaluated at GSFC. The Near Earth Network Services (NENS) contract will provide tracking and data acquisition services for near-Earth customer missions. Services under the Mission Operations and Mission Services (MOMS) contract will encompass all mission phases, including concept, formulation, development, operations, and decommission for Space Science and Earth Science missions at GSFC.

Evaluation of the proposals for both contracts is expected to continue throughout the summer with awards made some time in the fall of 2003. The NENS and MOMS tasks are scheduled to begin on January 1, 2004.

MSP Offers Outreach in Several Areas

It has been another active and rewarding season for MSP Outreach activity. In February, Phil Liebrecht celebrated National Engineer's Week by speaking to four classes at Takoma Park Middle School about the importance of engineering work going on in the Mission Services Program. Frank Stocklin, MSP Systems Engineer, spoke to University of Maryland graduate engineering students in May. Phil has also been working with NASA Headquarters to arrange an astronaut visit to a school in western Maryland. Merritt Island Launch Annex (MILA) Station Director Tony Ippolito provided a tour of MILA facilities for University of Florida students as part of a course on orbital mechanics. Finally, the TDRS Project has again been supporting Hope Chapel Academy and the DC Regional Botball competitions this year (see the article on page 8 for details on that activity).

By Rosemary Bruner/GSFC Code 450

For additional information on these and other outreach opportunities, please contact the author via telephone (301-286-2648) or email (Rosemary.V.Bruner@gsfc.nasa.gov).

TDRS Project Supports FIRST Robotics and Botball Competitions

For the second year in a row, the TDRS Project has provided funds to the Hope Chapel Academy in Hermosa Beach, CA, to enable the school's Beach Bot team to participate in FIRST (For Inspiration and Recognition of Science and Technology) Robotics Competitions. Also, for the second consecutive year, the Project has supported the Washington, DC Botball competition event.

The FIRST Robotics Championship Nationals held in Houston's Reliant Park, April 10-12, was the best showing yet for the Hope Chapel Academy's Beach Bot team. This year's team came in second place, losing by only one point, due to a small split-second strategy decision during play.

The Washington, DC Botball Tournament, which was held May 3, was a tremendous success. A number of GSFC civil servants and contractors served as team mentors or judges at the competition while others supported NASA display booths at the event. The University of MD's Ritchie Coliseum was a perfect setting for the competition. This year there were 49 teams participating—20 from Virginia, 24 from Maryland, and 5 from DC. The top competitors were:

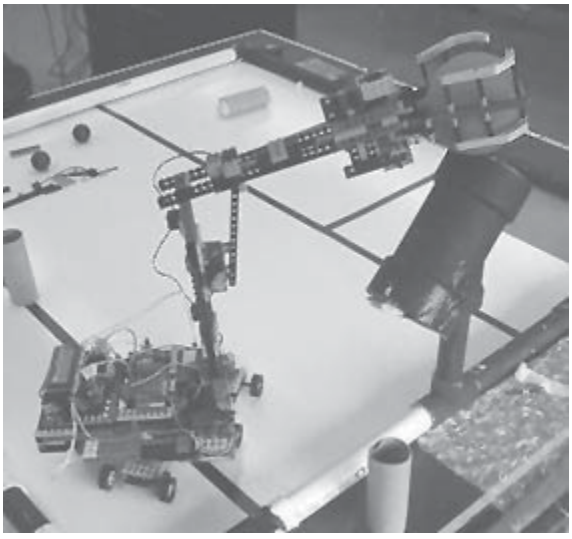
First Place:	Wootton HS, Rockville, MD
Second Place:	Springbrook HS, Silver Spring, MD
Third Place:	Glen Burnie HS, Glen Burnie, MD
Fourth Place:	Howard County School System's Applications & Research Laboratory, Clarksville, MD.
Fifth Place:	Congressional School of Virginia, Falls Church, VA

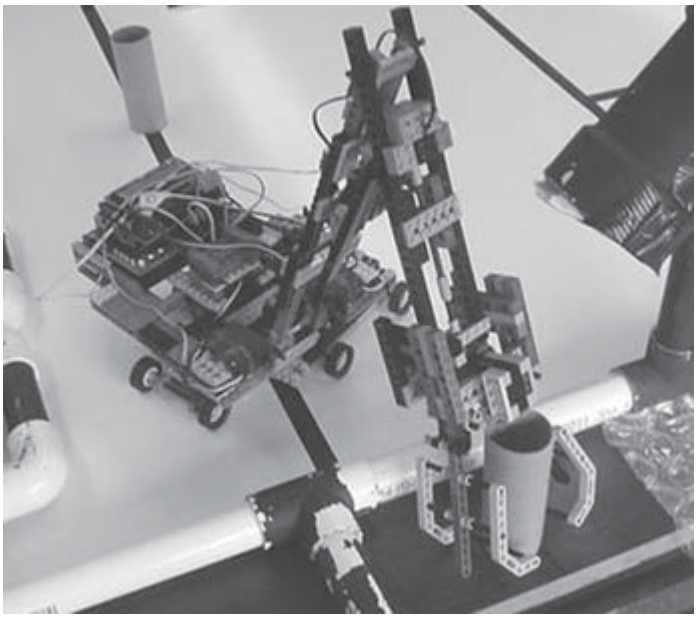
Wootton High School, the overall winner, will attend the National competition held in Norman, OK, June 28 – July 1, 2003.

These programs team up high school students (Botball competition) and middle and high school students (FIRST competition) with corporations and organizations such as NASA, GM, Johnson & Johnson, Motorola, and Xerox. In several intense weeks, students and engineers work together to design and construct a robot. Botball is played on a 4' x 8' board where robots score points by placing black or white balls in scoring position. The games in the FIRST competition vary from year to year. Robots use no remote control and are programmed by students. The students who design, build, compete, and repair these robots with guidance from engineers/mentors gain much respect for themselves as individuals and for engineers and scientists at large.

By Mary Lapelosa/Boeing

Visit the websites for Botball (www.botball.org) and FIRST (www.usfirst.or) for more information about these activities.





Wootton High School constructed the winning entry in the 2003 Washington, DC Botball Tournament. Photos of the robot are courtesy of Suresh Nidhiry, captain of the Wootton High School Robotics Club.

Customer Commitment Office

Join Us at the Next Mission Services Customer Forum…

The Mission Services Program (MSP) continues to convene a series of forums designed to bring MSP customers together to exchange information on a variety of subjects. Customer forums are held approximately every four months, and all customers and interested parties are invited to attend.

Of particular interest during the recent forum, held in the Building 3 Goett Auditorium at GSFC on July 17, 2003, were presentations on the status of the Tracking and Data Relay Satellite (TDRS)-I and -J spacecraft and a summary of the TDRS Continuation study.

Also discussed at the March forum were additional topics—the Space Network Access System (SNAS) and the Ka-band Transition Project (KaTP)—that are relevant to both new missions and those already on-orbit.

The SNAS will be capable of supporting all SN customers and will supply a cross-platform, compatible, network-based system that incorporates all the features from the SN Web Services Interface (SWSI), most features of the User Planning System (UPS), and other SN customer-required functionality. Customers will be able to schedule SN real-time support on-demand, and will also have tools to ease the scheduling process for long-term planning. (The SNAS web site is located at *http://snas.gsfc.nasa.gov/*.)

The KaTP consists of on-going activities to demonstrate the Ka-band frequency capability provided with the TDRS-H, -I, and -J spacecraft.

To access up-to-date information about the July 2003 forum and presentations from previous forums, visit the MSCF website at *http://msp.gsfc.nasa.gov/tdrss/mscf.htm.*

For additional information about the MSCF, please contact Mr. Allen J. Levine (301-286-9436; e-mail: Allen.J.Levine@nasa.gov).

The MSP plans to sponsor ***Mission Services Customer Forums*** *three times per year—in March, July, and November.*

Look for more information about these forums on the web at http://msp.gsfc.nasa.gov/tdrss/mscf.htm.

Space Network On-line Information Center

The Space Network (SN) On-line Information Center contains information modules beyond those for the Tracking and Data Relay Satellite System (TDRSS). You will still find authoritative information about TDRSS on the site, but we have now included information and links to other Mission Services Program and Space Network activities.

There are new links and information regarding the Ka Transition Project (KaTP)—a technology development, integration, and demonstration initiative to facilitate the transition of SN and Ground Network (GN) customers to the NASA-allocated Ka-band frequencies. We also include links to other MSP websites and up-to-date information on projects, such as the SN Web Services Interface (SWSI) and the Demand Access System (DAS).

In addition, you can link to numerous customer websites from the SN On-line Information Center. The telecommunication information module update is almost

(continued on page 10)

(continued from page 9)

complete and ensures that the information in the website is consistent with the Space Network Users Guide Revision 8. This users guide is also available for download at *http://msp.gsfc.nasa.gov/tdrss/guide.html*. We have updated the site's TDRS constellation information to now include the TDRS H, I, and J deployments.

If you have a specific question, email it to us using our feedback form. We will direct your question to the appropriate expert and promptly return an answer to you via email. As always, the calendar listing upcoming launches and other activities of interest is updated monthly. We review the entire site twice per month to ensure the information is current and accurate.

The SN On-line Information Center can be accessed at *http://msp.gsfc.nasa.gov/tdrss/*

Detailed information is currently available on:

- The Tracking and Data Relay Satellites (including TDRS H, I, J)
- Demand Access System
- The White Sands Complex, including WDISC
- Guam Remote Ground Terminal
- McMurdo TDRSS Relay Terminal System
- TDRSS Telecommunication Services
- Customer Communication Systems and Products (including Transponders)
- TDRSS Applications
- Plus much more…

By Jeff Glass/FHA

Integrated Design Capability Assists Potential MSP Customers

The NASA Integrated Design Capability (IDC) is a collaborative, concurrent engineering environment that produces design concepts and related analyses for space missions and remote-sensing instrumentation. IDC success is built on the people, process, tools, and facility paradigm as depicted in Figure 1.

Skilled Goddard engineers work with Investigator Teams (e.g., scientists, proposal/project managers, engineers, etc.) in the IDC's collaborative environment to produce detailed space mission designs, remote sensing instrument designs, and/or technology assessments. IDC services include end-to-end and focused studies, independent peer reviews, as well as technology and risk assessments. The IDC activities are primarily carried out in

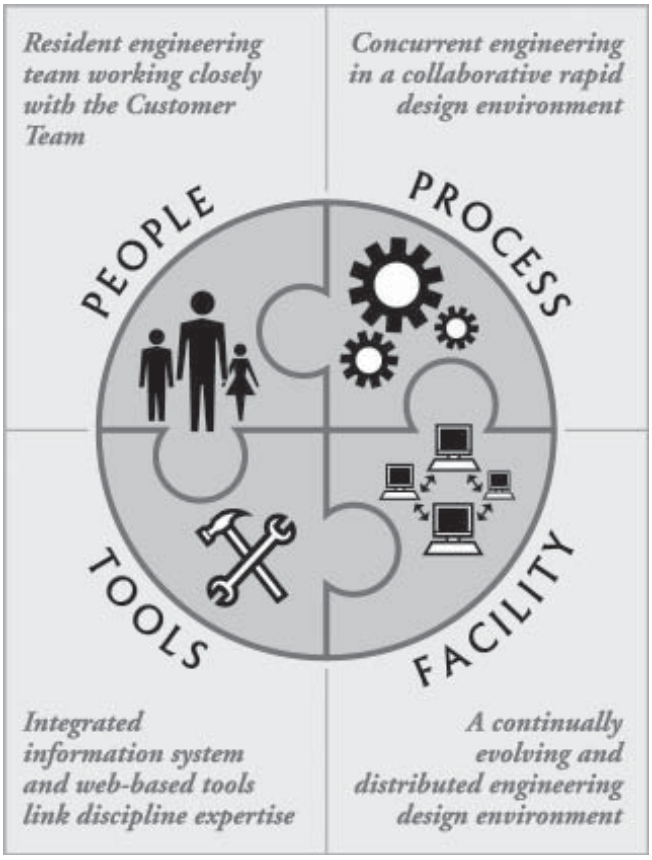


Figure 1. The IDC operates according to the paradigm depicted above, which allows IDC team members to effectively assist potential MSP customers.

one of two closely related rapid design centers, the Integrated Mission Design Center (IMDC), and the Instrument Synthesis & Analysis Laboratory (ISAL).

The design centers tailor a study session to fit an investigator's specific needs. Services are primarily geared to support teams in preformulation or formulation. The IDC product is in direct alignment with the role of the MSP's Customer Commitment Office. The IDC also provides valuable services to teams in early implementation.

The IDC paradigm has resulted in the successful execution of over 160 IMDC studies since 1997 and nearly 50 ISAL studies since 1999. Approximately 40% of IDC studies have been in support of Goddard's directed missions, 40% in support of competed proposals, with the remaining 20% in various other support areas. While primarily supporting a Goddard customer base more or less equally apportioned across Earth and Space Sciences, the IDC also provides services to the other NASA Centers, JPL, other Federal agencies, and academia.

Personnel from the MSP's Customer Commitment Office play critical roles in the IMDC. John Martin, as the IMDC Team Lead, has led over 110 IMDC studies over the last three years. Prior to transitioning to the Team Lead role in 1999, John was the lead for IMDC data/ground segment analysis. Larry Phillips has been a member of the IMDC team since August 2001, and has supported over 40 studies as the IMDC launch vehicle discipline engineer. Recently, Larry has assumed additional responsibilities as an IDC cost analyst, developing parametric cost models for both IDC spacecraft and instrument design concepts. Leslie Ambrose has also provided frequent support to the IMDC since August 1999, supporting over 50 studies as a member of the IMDC data systems group.

IDC support can range from one-day brainstorming sessions, to multi-week design sessions. Design team personnel work with the Investigator Team prior to a design session to understand the mission goals and objectives, the science driving requirements, the instrumentation, mission configuration, architecture, as well as the goals of the design session. During the study execution phase, the Investigator is a key participant in the IDC collaborative process. This partnership engages the Investigator in the design process and provides him/her the opportunity to influence and refine the study objectives and trade decisions throughout the design process. This process enables the IDC to make the best decisions in real time and has been proven to result in a superior product that meets the Investigator's needs.

IDC products include mission and/or instrument design concepts [e.g., overall baseline architecture(s) with mass/power/data rate/ cost rack ups; mechanical drawings; access to space recommendations; data transport options; mission operations approach; engineering analysis; documented trades; technology needs, issues and risks, etc.] as well as the supporting analysis, engineering models, CAD files, grass roots, and parametric cost estimations, etc.

By Ellen Herring/IDC Operations Manager

To obtain additional information on the IDC or to discuss the scheduling of an IDC study, please contact the author at 301-286-7393, via email at Ellen.L.Herring@nasa.gov, or visit the IDC web page at http://idconline.gsfc.nasa.gov/.

EO-1 Exceeds Expectations

Earth Observing-1 (EO-1) is the first satellite in NASA's New Millennium Program Earth Observing series. The goal of the one year EO-1 mission was to flight-validate three revolutionary land imaging instruments along with ten other new technologies. The instruments are meant to ensure the continuity of Landsat data into the foreseeable future.

EO-1 was launched on a Delta II from Vandenberg Air Force Base on November 21, 2000 and was inserted into a 705 km circular, sun-synchronous orbit at a 98.7 degrees inclination. EO-1 orbits in formation one minute behind Landsat-7 on the same ground track and is part of the AM constellation, which includes Landsat-7, Terra, and SAC-C.

As a one-year technology validation mission, the EO-1 spacecraft has little onboard redundancy; two of the instruments observe a smaller swath of land than Landsat-7, and the science data recorder—itself a new technology—has a limited capacity. The original requirements were to collect up to four images per day for a total of 1,000 images.

Immediately after launch, the EO-1 team initiated an accelerated mission profile to ensure a successful mission. The goal of the accelerated mission was to prioritize mission objectives and complete them as quickly as possible, given the fragile nature of the spacecraft. Using this approach, the validation of the Advanced Land Imager instrument was completed in three months instead of twelve. In fact, 90% of all technology validations were completed by May 2001. By December 2001, EO-1 had collected over 2,500 images, 2.5 times the original objective.

By this time, the value of the science data from another of EO-1's new instruments, the Hyperion hyperspectral imager, became apparent. One of the first hyperspectral instruments on orbit (the other is EO-1's other hyperspectral instrument, the Atmospheric Corrector) its 220 spectral bands allow the Hyperion not only to image Earth but also to classify and evaluate surface features. Using Hyperion data, scientists can determine the types of plants that are growing on Earth and how healthy they are. Hyperion can also determine the types of minerals present on Earth's surface. Hyperspectral imaging has wide-ranging applications in mining, geology, forestry, agriculture, and environmental management.

(continued on page 12)

Artist's rendering of the EO-1 satellite

(continued from page 11)

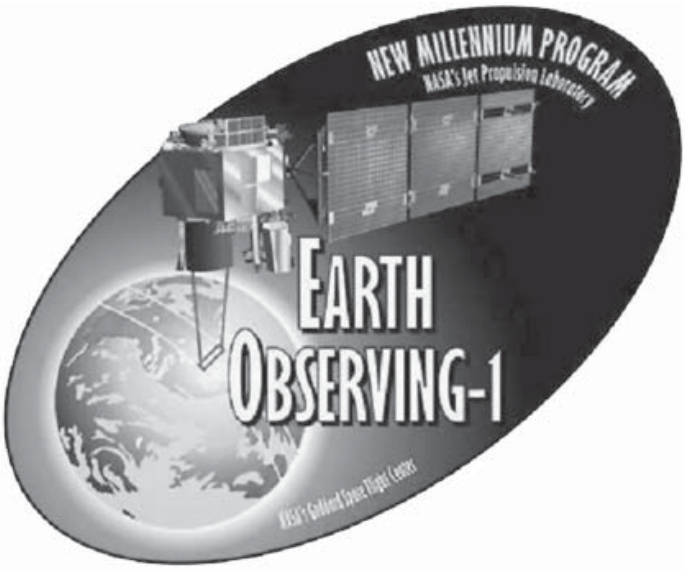
The demand for Hyperspectral data helped secure an extended mission for EO-1. NASA partnered with the United States Geological Survey (USGS) to commercialize EO-1 science data. The cost of an EO-1 image was driven down by streamlining the data ordering, processing, and delivery process at the USGS facility in Sioux Falls, South Dakota and by increasing the possible number of images EO-1 can take each day. EO-1 now routinely takes over 23 images per day, and the maximum number of images taken in a single day is 29. To date, EO-1 has acquired well over 10,000 images.

Not being able to rest on its laurels, EO-1 has entered a new phase of its ongoing mission. In cooperation with scientists from government and academia, EO-1 has become an orbiting test bed. While still taking commercial imagery, EO-1 is now being used to demonstrate advanced onboard autonomy software, onboard cloud cover detection, autonomous inter-satellite collaboration, onboard science data compression, and phased array ground station antennas. Several other testbed efforts are in the planning stages.

EO-1 has proven that a little creative thinking can transform a straightforward mission into an orbiting "jack-of-all-trades" that maximizes its value to the public. Stay tuned for another EO-1 update to see what we are up to next…

By Robert Boté/HTSI

For additional information about EO-1, please visit http://eo1.gsfc.nasa.gov or http://eo1.usgs.gov or contact Dan Mandl/EO-1 Operations Manager (Daniel.J.Mandl@nasa.gov).



Eddy or Not, Here They Come!

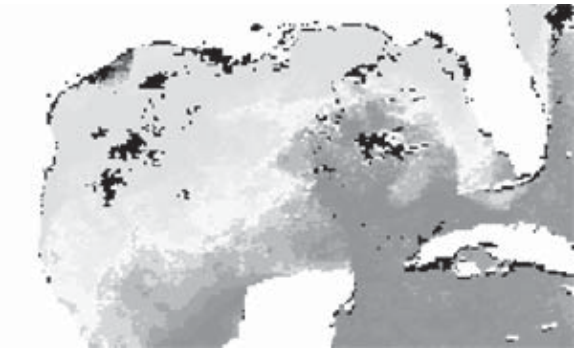
The U.S.-French TOPEX/Poseidon (T/P) satellite continues to function well as the Project approaches the 12th anniversary of its launch in August 1992. A six-month cross-calibration period between T/P and Jason-1 was completed last year, and the T/P orbit was successfully modified in August-September 2002 through a series of propulsive maneuvers to enhance overall science data quantity and quality in the joint "tandem" mission arrangement.

The Tandem Mission concept was first envisioned and formulated by the TOPEX/Poseidon and Jason-1 Science Working Team (SWT) in 2000, and culminated in a November 2001 report issued by the SWT High-resolution Ocean Topography Science Working Group (HOTSWG) endorsing the plan. By placing T/P in this modified ground track, bisecting its original orbit, cross-track spacing between observations was cut in half (from 310 km to 155 km at the equator).

One of the science benefits of this increased resolution has been an enhanced understanding of ocean features known as "eddies," which are relatively small, short-lived ocean circulation patterns. Eddies are often observed in rivers or lakes, where currents or running water are present, and appear as whirlpools or cyclonic patterns on the surface. This phenomenon also occurs in Earth's atmosphere, where eddies are observed as spinning pools of air in the form of high/low pressure or weather systems.

Ocean eddies can be only a few kilometers across, or can sometimes exceed 300 km in diameter; they can persist for hours, days, or even months. Eddies generally originate as "cold' or "warm" water events, depending on where and how they form. Since warm ocean water has a higher relative surface height than the surrounding water (and conversely, cold water is lower), these features can be tracked and monitored by TOPEX/Poseidon and Jason-1 radar altimeters. Due to the original 310 km distance between T/P ground tracks, some of the smaller eddies could not be readily observed. However, reduction of this spacing to 155 km has now allowed many more of these events to be studied.

Eddies can actually be thought of as a type of oceanic weather and clearly occupy an important role in ocean circulation. In the open ocean, eddies facilitate the flow of nutrient-rich water from deep oceanic water to the surface, and are known to be an integral part of the global carbon cycle. Marine mammals and fish congregate to feed at the edges of cold water eddies, while larger cold and warm water eddies actually affect the local atmospheric weather in their proximity. Eddies also impact marine oil and gas drilling operations, as extreme water currents and temperatures can adversely affect offshore oil rigs and platforms.



View of the Gulf of Mexico "loop current" as it begins to shed an eddy (darker intrusion off the main portion) into the Gulf

Recently, promising research in this field has centered on using reflected signals from the Global Positioning System (GPS) satellite network. Using these signals, it has been demonstrated that it is possible to determine sea-surface height over an area of ocean with sufficient accuracy to map oceanic eddy events. This data could eventually be utilized to augment the highly accurate T/P and Jason-1 altimetry measurements and, in turn, improve the next generation of climate models.

Research into ocean eddies is only one of the many significant science results enabled by the T/P and Jason-1 missions. The flight team is currently supporting the tandem mission here at the JPL Earth Science Mission Center, where we also monitor the ACRIMSAT and QuikSCAT satellites. Both the T/P and Jason-1 spacecraft continue to operate well, and the flight team is confident that both missions will continue to achieve new scientific objectives and milestones that will be a benefit to all.

By Mark Fujishin/Manager, JPL Earth Science Mission Operations

Aqua Celebrates First Anniversary

Aqua mission operations and science team personnel celebrated Aqua's first successful year of on-orbit operations with a dinner banquet at the GSFC Recreation Center on May 28, 2003. After opening remarks by Center Deputy Director, William Townsend, and Aqua's Project Scientist, Dr. Claire Parkinson, the audience was treated to an after-dinner talk by Dr. Ghassem Asrar, NASA's Associate Administrator for Earth Sciences. Dr. Asrar commended the audience on their efforts in getting Aqua to orbit and the instruments checked out in what was deemed by Mr. Townsend to be one of the smoothest, trouble-free, in-orbit checkout periods in recent memory. Dr. Asrar also reminded the audience that, with the average life-span of Earth Science missions being over a decade, this is just the beginning. He is looking forward to many more years of successful operations and the exciting scientific discoveries of all of the Earth Science missions.

The Aqua mission is a part of the NASA-centered international Earth Observing System (EOS). Formally called the EOS PM-1 mission to signify its afternoon equator crossing time, the satellite was successfully launched onboard a Delta II rocket from the Western Test Range on May 4, 2002.

"Aqua," which in Latin means "water," is the second of the large Earth Observatories in the EOS Program, and is so named for the large amount of information that Aqua's instruments will collect about the Earth's water cycle. In particular, the Aqua data will include information on water vapor and clouds in the atmosphere; precipitation from the atmosphere; soil wetness on the land; glacial ice on the land; sea ice in the oceans; snow cover on both land and sea ice; and surface waters throughout the world's oceans, bays, and lakes.

During its six-year mission, Aqua will gather information on changes in ocean circulation and help determine how clouds and surface water processes affect our climate. This information will help scientists better understand how the global ecosystems are changing and how they respond to and effect global environmental change.

A joint effort between the United States, Japan, and Brazil, Aqua carries six state-of-the-art instruments. The United States provided the spacecraft and four instruments—NASA's GSFC provided the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Microwave Sounding Unit (AMSU), JPL provided the Atmospheric Infrared Sounder (AIRS), and NASA's Langley Research Center (LaRC) provided the Clouds and the Earth Radiant Energy System (CERES) instrument.

Japan's National Space Development Agency (NASDA) provided the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) instrument, and Brazil's Instituto Nacional de Pesquisas Espaciais (INPE), the Brazilian National Institute for Space Research, provided the Humidity Sounder for Brazil (HSB).

Each instrument has its own unique characteristics and capabilities, and together, they form a powerful package for Earth observations. In addition to the data on the water cycle, Aqua will provide improved atmospheric temperature data, which when combined with humidity measurements have the potential to enable improved weather forecasts.

The Aqua spacecraft as well as its sister spacecraft Aura (formally called EOS Chemistry), which is scheduled for launch in January 2004, was designed and built by the Northrop Grumman Space Technology (NGST) Company (formally known as TRW) in

(continued on page 14)

(continued from page 13)

Redondo Beach, California. Based on NGST's modular, standardized common spacecraft bus, this design features common subsystems that are scalable to mission-specific needs. Instrument payloads can be attached on a "mix-and-match" basis without changing the overall design or subsystem support requirements.

Launch and Orbit

Aqua was launched at 5:55 a.m. Eastern Daylight Time on May 4, 2002 from the Vandenberg Air Force Base on board a Delta II 7920-10L rocket. Injected into a near-polar low-Earth orbit with a mean altitude of 685 km, the spacecraft was raised to its operational altitude of 705 km over the next 44 days using a series of six ascent burns that concluded on June 17, 2002. The ascent burn sequence was purposely designed to phase the Aqua orbit with respect to the Terra orbit such that over the polar ground stations the Aqua satellite would trail the Terra satellite by approximately 20-minutes. Aqua's operational orbit is near-polar with an inclination of 98.2 degrees, and is sun-synchronous in that it always crosses the equator at the same mean local time.

Figure 1: The May 4, 2002 Aqua launch

Figure 2: "The Aqua Flight Operations Team (FOT) excitedly views the Aqua launch onscreen in the control room at GSFC.

In this orbit Aqua circles the Earth every 98.8 minutes and crosses the equator at 1:30 P.M. local time going north in orbital daylight at the ascending node, and 1:30 a.m. local time going south during orbital night at the descending node. This is in contrast to the Terra orbit and the Morning Constellation (Landsat-7, EO-1, SAC-C, and Terra) that move south across the equator at roughly 10:00 – 10:45 A.M. mean local time at the descending node (while in orbital daylight).

Since Aqua crosses the equator at 1:30 p.m. local time, it has assumed the lead position in what has been referred to as the Afternoon Constellation.

In-Orbit Checkout

After launch, Aqua underwent a 120-day checkout period during which the functionalities of the instruments and spacecraft subsystems were thoroughly tested and verified. Between May 12, 2002 and June 24, 2002 all six instruments were checked out and began producing their combined dataflow of 89 GB/day (8.23 Mb/sec). On July 12, 2002, after all six instruments were operating, the Aqua direct broadcast system was turned on. This system allows direct access to the raw Aqua data by anyone with direct broadcast receiving equipment.

On August 27, 2002, NGST (still TRW at the time) formally turned mission operations of the Aqua spacecraft over to Goddard's Earth Science Mission Operations (ESMO) Project (Code 428) staff and the Lockheed-Martin Flight Operations Team (FOT). Bill Guit, the NASA/ESMO Mission Director for Aqua, is shown receiving the ceremonial key to the spacecraft from NGST's Project Manager, Dana Southwood in Figure 3. Finally, on September 1, 2002, when the Aqua mission completed its 120-day checkout period, the mission was declared fully operational.

Figure 3: TRW's Project Manager, Dana Southwood, (right) hands over Aqua operations to the Goddard Mission Director, Bill Guit, by presenting him with a key to the spacecraft. TRW (now called NGST) led spacecraft operations during the checkout period and formally handed over operations to the staff of the Earth Science Mission Operations (ESMO) Project and the Lockheed-Martin Flight Operations Team at the ESMO Receiving Review conducted August 27, 2002.

Recent Aqua Awards

The Aqua satellite won a 2002 Best of What's New Award from "*Popular Science*" and the Aqua team of scientists and engineers from the GSFC and Northrop Grumman Corporation received the Nelson P. Jackson Aerospace Award for 2003 from the National Space Club.

By Bill Guit, Aqua Mission Director/GSFC Code 581

For more information about Aqua on the Internet, visit http://aqua.nasa.gov.

ADEOS-II Checkout Phase Successfully Completed

During the week of May 20, 2003 representatives from NASDA, NASA, NOAA, JPL, and CNES met in Japan for the ADEOS-II Routine Operations Readiness Review (RORR) and the 9th Joint Program Meeting.

The purposes of RORR were to review ADEOS-II checkout results (including provided sensors and NASA/NOAA ground systems), to identify suspended issues, and to confirm transition to the Calibration and Validation (CAL/VAL) Phase that started on April 15. Following a successful CAL/VAL Phase (Initial Operation and Evaluation Phases II and III), the Routine Operations Phase is targeted to start on December 14, 2003.

At the RORR, each ADEOS-II instrument and mission support team presented reports from the Initial Checkout Phase activities (conducted January 10-April 9, 2003) that included System Test 1 (March 19-23, 2003) and System Test 2 (April 2-9, 2003).

The meeting was full of positive energy and happy faces from the very enthusiastic teams. The following are quotes from the various presentations:

Global Imager (GLI): "Checkout was completed successfully. . . . all planned evaluation finished. . . no major concerns."

Advanced Microwave Scanning Radiometer (AMSR): "all commands reached AMSR and were executed properly. . . . both S-band and X-band data have been nominal. . . . AMSR has been in good condition. . . . AMSR has collected useful data."

SeaWinds: "SeaWinds operated continuously since early turn-on (January 11, 2003) with no significant problems. . . . instrument ground command interfaces verified. . . checkout activities completed as planned. . . . the Ground Data System has processed all received data. . . . preliminary wind product evaluation is very good (correlates well with other data sources: QuickSCAT, ECMWF/NCEP). . . . 99% of planned passes resulted in successful data delivery to SW GDS."

ADEOS-II Spacecraft: "two anomalous points were found at tape count 110 and 181 on Mission Data Recorder #2 (from total of 3 recorders)/ probability of data loss is extremely small. . . . subsystem checkout results: OK. . . spacecraft has been working well in Routine Operations since April 14."

Polarization and Directionality of the Earth's Reflectances (POLDER): "successful checkout tests. . . trend analysis performed confirmed a good stability of instrument parameters."

ADEOS-II NASA/NOAA Ground Network (NGN): "so far 98.9% success rate"

During the 9th ADEOS-II Joint Program Meetings, the science and support teams discussed preliminary data results, calibration and validation plans and procedures, data release, distribution and utilization plans, science status, and algorithm improvements.

(continued on page 16)

(continued from page 15)

Representatives from each instrument program shared the first images from their respective instruments. NASDA emphasized their focus on strengthening efforts to promote data utilization.

By Carlos Gomez, ADEOS-II Program Manager/GSFC Code 581

For additional information, please contact the author via email (Carlos.Gomez@nasa.gov) or telephone (301-614-5087).

Participants in the ADEOS-II Routine Operations Readiness Review (RORR) and Ninth Joint Program Meeting, held in Japan in May 2003.

Landsat-7 Shifts Its Ground Network Ops Concept

The Landsat Program successfully revised its ground network support concept for Landsat-7, shifting normal operations Telemetry, Tracking and Command (TT&C) support from the Polar Ground Network sites to the Alice Springs, Australia ground station. The transition occurred on April 9, 2003 after a successful Operations Readiness Review. Coincident with the transition, Landsat-7 discontinued use of the Alaska Ground Station (AGS).

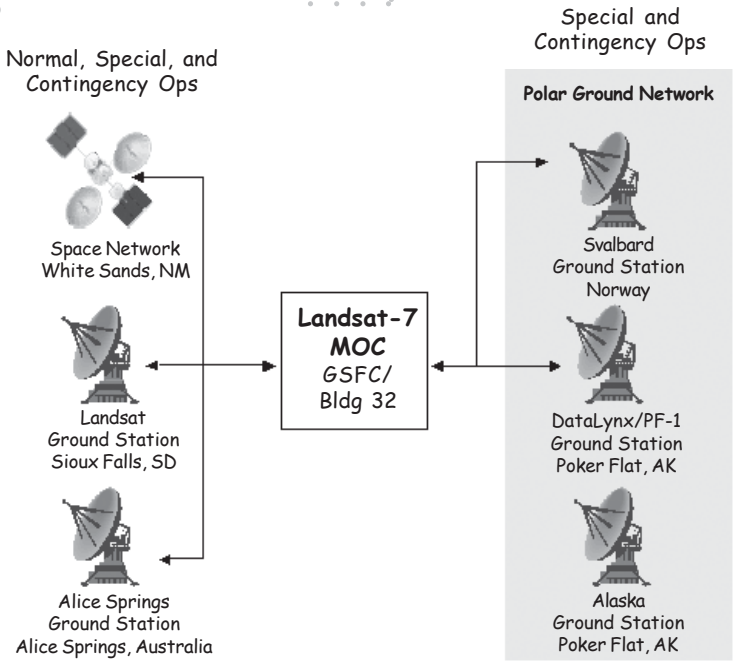
The new ground network operations concept was formulated during the prior year, after the United States Geological Survey (USGS) considered several alternatives for ground stations and network concepts. Alice Springs is already a Landsat team member, receiving real time image data as an International Cooperator. The site required upgrades for S-Band operations and installation of Ampex recorders for capture and shipment of X-Band image data.

The revised network concept offers significant recurring savings for network service costs to the Landsat Program.

The Polar Ground Network stations at Svalbard, Norway (SGS) and Poker Flat, Alaska (PF-1) continue to provide special and contingency support to Landsat-7 as needed. Monthly proficiency contacts ensure readiness of both the ground station and Flight Operations Team personnel.

By Tegan Collier/Honeywell Technology Solutions Inc.

For additional information about Landsat-7, go to http://landsat7.usgs.gov/index.php .



The new Landsat-7 ground network support operations concept

Solar Dynamics Observatory Ground Station To Be Located in White Sands, NM

The decision has been made to use the White Sands Complex (WSC) to host a dual-antenna ground station and a Data Distribution Center (DDC) for NASA's upcoming Solar Dynamics Observatory (SDO) mission. During the first week in August 2003, NASA representatives will draft a Memorandum of Understanding to secure the WSC facilities for the project.

SDO is the flagship mission in the Agency's Living With A Star Program and will collect data from the solar atmosphere to help scientists understand the Sun's influence on Earth and near-Earth space. The SDO spacecraft will be placed in a geosynchronous orbit, hovering approximately 38,000 km above Earth in full view of the WSC. Originally, SDO's station was to be located at a longitude of 104 degrees. Plans now call for a 102-degree position to avoid the natural "gravity well" present at 104 degrees and the space debris that tends to collect there.

The SDO ground station at WSC will consist of two fully redundant, nine-meter antennas capable of receiving and transmitting S-band and Ka-band data. The prime antenna will be located at Cacique (the White Sands Ground Terminal) with the backup at Danzante (the Second TDRSS Ground Terminal). The DDC will be located at Cacique and will receive, store, and distribute SDO raw data, but will not perform data processing functions. Both the DDC and the dual antenna network will be controlled from the SDO Mission Operations Control Center in Building 14 at the Goddard Space Flight Center.

Currently, SDO is investigating network support options for the launch and early orbit phase, and the geosynchronous transfer orbit phase, when SDO moves from a separation altitude of 300 km to its 38,000 km station orbit. Among the several alternatives being considered are the Universal Space Network (USN), Honeywell's DataLynx system, and JPL's Deep Space Network (DSN).

For more information, please contact Raymond Pages via email at Raymond.Pages@nasa.gov.

All Aboard the A-Train!

With Aqua successfully on-orbit (see article on Aqua on page 13) the efforts of GSFC's EOS Program Office (Code 420) are now focused on managing the integration and testing of the Aura spacecraft as it prepares for its January 29, 2004 launch date. Aura's suite of instruments is designed to study issues related to air quality, stratospheric ozone, and climate change. Once on-orbit, the Aura and Aqua missions will occupy the front (Aqua) and back (Aura) orbital positions of the Afternoon Constellation, or what has come to be known as the A-Train.

Over the next five years, NASA's Earth Science Enterprise plans to launch four satellites that will fly in close proximity with each other and the Aqua satellite. In addition to Aqua, the A-train satellite formation will consist of three Earth System Science Pathfinder (ESSP) missions (CALIPSO, CloudSat, and OCO), a French Space Agency mission (PARASOL), and Aura.

The CloudSat and CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) missions are co-manifested and are expected to be launched in the fall of 2004.

The Polarization and Anisotropy of Reflectances for Atmospheric Science Coupled with Observations from a Lidar (PARASOL) satellite is to be launched by the French Space Agency in 2005.

The sixth mission that is now expected to be part of the A-Train is the ESSP mission termed the Orbiting Carbon Observatory (OCO). This mission, which was recently selected, is expected to be launched in 2006 or 2007. Once on orbit, OCO will be positioned in an orbit ahead of Aqua by 15-minutes, effectively becoming the new lead satellite of the A-Train.

The Whole is Greater than the Sum of its Parts

The A-Train formation will allow for synergistic measurements where data from several different satellites can be used together to obtain comprehensive information about various key atmospheric components or processes. Combining the information from several sources gives a more complete answer to many questions than would be possible from any single satellite taken by itself.

Challenges of Formation Flying

In order for the planned synergistic measurements to be successfully obtained, the formation will need to be precisely aligned. This calls for coordinated maneuvering of the various spacecraft to keep them in a tight formation. For example, Aqua and Aura have to maneuver frequently to maintain proper positioning to allow for correlative measurements with the other

(continued on page 18)

(continued from page 17)

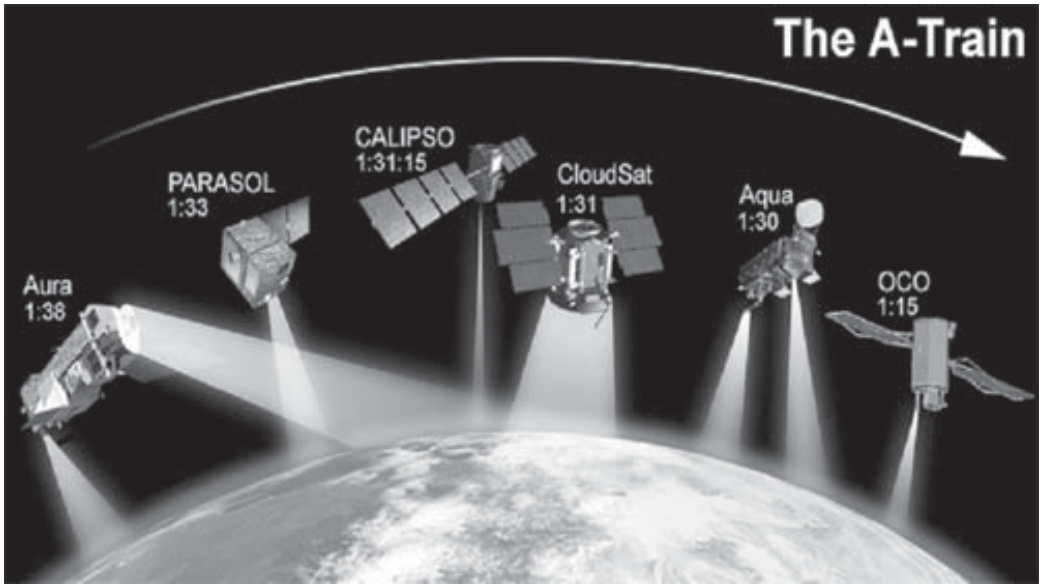
members of the A-Train. In addition, CloudSat must maintain an extremely tight formation with CALIPSO to allow the CloudSat radar footprint and the CALIPSO lidar footprint to observe the same scene within 15 seconds of each other.

Promise of Formation Flying

These challenges not withstanding, it is evident that the A-Train formation offers unprecedented opportunities to study important questions related to climate change. There are many specific questions that may be answered by data collected by this formation. The information should substantially improve scientists understanding of the important role that clouds and aerosols play in regulating the Earth's climate. It should lead to a much better understanding of the chemistry of our atmosphere, how the various atmospheric constituents interact with one another, and what impact changes in the chemical composition of the atmosphere are having on the Earth's climate. Taken together, data from these missions will do much to increase our understanding of the health of our home planet.

By Bill Guit, Aqua Mission Director/GSFC Code 581

For additional information on Aura, please visit http://eos-chem.gsfc.nasa.gov/.



The A-Train will consist of six spacecraft—Aqua, plus five others that will be launched over the course of the next several years. Formation flying will enable the A-Train spacecraft to make synergistic measurements of Earth-based phenomena. Together, these datasets will be more valuable than information obtained from a single spacecraft, since scientists will be able to use them in combination to glean information about Earth's atmospheric processes.

*In addition to **Aqua** and **Aura**, four other spacecraft will make up the **A-Train formation**.*

To learn more about these spacecraft, visit the following web sites:

*For **CloudSat**:*
http://cloudsat.atmos.colostate.edu/cloudsat.html

*For **CALIPSO**:*
http://www-calipso.larc.nasa.gov/

*For **COC**:*
http://essp.gsfc.nasa.gov/oco/index.html

*For **PARASOL**:*
http://smsc.cnes.fr/PARASOL/

CODE 452

Space Network Project

SNAS Review Held

The Space Network Access System (SNAS) will provide a single, universally accessible, low-cost, cross-platform, standards-based customer interface for performing SN scheduling and real-time service monitoring and control. SNAS will consolidate the functionalities of the SN Web Services Interface (SWSI) and the User Planning System (UPS) and legacy customer real-time ground systems into a single system. SNAS will replace the UPS and SWSI as the primary scheduling interface between the SN customer and the SN.

The SNAS Requirements Phase is now complete. Over the last three months, the SNAS team has accomplished extensive analysis of the SWSI and UPS. We conducted numerous interviews with members of the SN customer community and compiled customer feedback on requirements needs. We conducted an independent peer review of the SNAS System Requirements and Operations Concept in early July and the SNAS Systems Requirements Review was held July 8, 2003.

By Joe Stevens/Code 565

For further information about SNAS, contact the author via email (joe.stevens@nasa.gov) or telephone (301-286-1557).

STARS Paves the Way for Space-based Range Safety Support

The Space-Based Telemetry and Range Safety (STARS) Study is a joint project of GSFC/Wallops, Kennedy Space Center (KSC), and Dryden Flight Research Center (DFRC). STARS will demonstrate the feasibility of using a space-based platform for range customer and range safety support. The end goal of using a spaced-based link for range support is to reduce the operational costs of ground-based assets, particularly to cover over-the-horizon tracking. Achieving this feat will not be a simple task; in fact, we are just starting.

The STARS project was initiated as a result of proposals submitted by DFRC and KSC/GSFC in response to the 2nd Generation Launch Vehicle program (this program has since become the Next Generation Launch Technology). Due to similarity in the proposals, the 2nd Generation program recommended combining the two proposals into a single study, and funding began in January 2001. The Space Network is being used as the space-based link for STARS.

The STARS demonstration consists of two parts—the range safety subsystem and the range customer subsystem. The range safety subsystem sends vehicle GPS position data to the range control center via a Space Network return link, and receives flight termination commands from the control center via a Space Network forward link. The range safety subsystem also receives identical flight termination commands from a launch head transmitter on the ground. The two links provide redundancy and help overcome multipath effects that would be observed initially at launch. The range customer subsystem demonstrates general telemetry link support through the Space Network for launch and test vehicles. The two subsystems are being flown and tested on

(continued on page 20)

(continued from page 19)

a series of flights using an F-15B aircraft this summer at Edwards Air Force Base. The first test flight was conducted June 3 and went very well. The rest of the flights are scheduled throughout June and July.

STARS payload location on the NASA F-15B

GSFC/Wallops and KSC are heading up the range safety portion of STARS. GSFC/Wallops is responsible for integrating and testing the satellite transceiver, amplifiers, and RF components. KSC has developed the Command and Data handling (C&DH) unit that is formatting the return link data (10 kbps) and is processing the received flight termination command data (400 bps). The vehicle transceiver used is a second generation Low Power Transceiver (LPT), who is also providing mission support. The STARS LPT consists of two receiver modules, each of which receives identical forward link data from the Space Network and the launch head, using different PN codes. The C&DH unit processes the four received streams (two on each receive module) and determines the appropriate flight termination response. A GPS receiver is also integrated to generate vehicle position and velocity data. Patch antennas on the top and bottom of the aircraft support the range safety and range customer links through the Space Network's S-band Single Access (SSA) service. Range safety subsystem services at GSFC/Wallops are being provided by Code 567 and 569, and CSOC SODA 43.

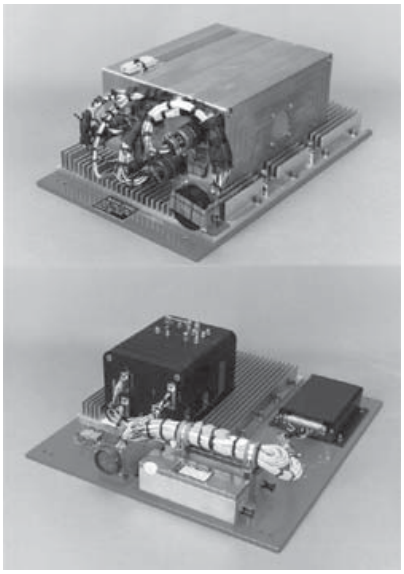
DFRC is responsible for the range customer subsystem as well as aircraft and test range support. The range customer payload for the first demonstration flights consisted of a 20 W biphase shift keying (BPSK) telemetry transmitter. Data rates of 125 kbps, 250 kbps, and 500 kbps through the Space Network return link were evaluated during flight.

The test flights at Edwards maximized dynamic conditions to assess link performance. Roll and bank maneuvers, cloverleafs, and supersonic flights to and away from TDRSS were included in the series of flights. Aircraft position and attitude data were analyzed in quick-look and are being processed postflight to assess payload tracking and acquisition performance.

A second and third flight demonstration (FD#2 and FD#3) series are planned. Project personnel are developing an integrated LPT, C&DH, and GPS unit for FD#2, scheduled for fall 2004. A couple of key building blocks in this series of flights will be data latency performance and higher range customer data rates (up to 5 Mbps) using a Ku-band phased array antenna. The project is also investigating supersonic flight on new technology vehicles for advanced environment testing. The STARS team is taking steps toward use of advanced range technologies and is looking forward to the future.

By Steve Bundick/GSFC/WFF Code 569 and John Smith/Lockheed Martin

For more information on STARS, please contact Steve Bundick via email (Steven.N.Bundick@nasa.gov) or telephone (757-824-1424).



C&DH and LPT Payload Pallets

Ultra High Data Rate Ka-Band Data Service In Store for the SN

As a follow-on activity to the Ka-Band Transition Project, the ongoing Ka-Band Data Service Project will implement end-to-end Ka-band return data services for Space Network (SN) customers requiring data rates up to 1.2 Gbps. The project team has been working since early this year to develop an operations concept document, perform customer requirement surveys, develop a draft ground station architecture, and perform modulation and coding trade studies. A team goal is to complete a System Requirements Document (SRD) by the end of September 2003. An interim review was held on May 1 where the following topics were presented:

- Customer requirement survey results
- Operations concept overview
- Proposed ground architecture
- Modulation and coding trade study results
- Draft end-to-end test system requirements
- Proposed System Requirements Document outline.

Some key decisions resulting from the review include:

1. A requirement for TDRS single access antenna autotrack will be included in the SRD for the 650 MHz-wide channel Ka-band return service.
2. A maximum data rate goal of 1.2 Gbps was established for the project. Based on simulation results, this goal is feasible using the TDRS 650 MHz-wide Ka-band channel on TDRS-8, 9, and 10. The simulation results presented at the review indicate that Staggered Quadrature Phase Shift Keying (SQPSK) modulation can support rates from 300 Mbps up to 1000 Mbps with the use of high-powered error correction coding such as turbo product codes (TPC) or low density parity check codes (LDPC). For data rates up to 1.2 Gbps, 8-PSK (Eight-Phase Shift Keying) modulation provided the best performance, also using TPC or LDPC codes.
3. A pooled receiver architecture will be implemented at the White Sands Complex (WSC) for the new high data rate receivers needed to support the Ka-band data service. The existing architecture uses dedicated prime and redundant equipment chains for each space-ground link terminal. The pooled concept will provide a higher Ka-band Single Access Return (KaSAR) service availability at a lower equipment cost.
4. A Ka-band forward and return end-to-end test (EET) system will be implemented under this project with capabilities similar to the existing S- and Ku-band EET systems at WSC.
5. The existing Ka-Band Transition Project SRD will be revised to include the requirements for the new Ka-band (650 MHz-wide) data service, rather than developing a new SRD for the Ka-Band Data Services.

Between now and the end of this fiscal year, the project team will continue to refine the ongoing trade studies (e.g., modulation and coding trade study) and ground architecture, complete the operations concept document, and perform the necessary requirements analyses to support the development of the SRD. Also, the team will prepare an SN Ka-band customer flight system concept document, a ground architecture document, and a Ka-band Internet Protocol (IP) study white paper by September 2003.

The above activities will be followed by the specification, procurement, and implementation of new WSC hardware and software modifications. Selection of compatible customer flight communication system components will occur in time to commence SN ultrahigh rate Ka-band data services in 2006. The Microwave and Communications Systems Branch (Code 567) will support the specification and procurement of a Ka-band flight system, including a transmitter and antenna for data rates up to 1.2 Gbps.

Visit the Ka-Band Website at*: http://classwww.gsfc.nasa.gov/kaband-updates/* to learn more about Ka-band transition activities within the Mission Service Program.

By Mark Burns/ITT Industries

For further information contact Yen Wong (301-286-7446)

Demand Access System Development Update

In March 2003, *The Integrator* provided information on the status of Demand Access System (DAS) integration and test activities, premission testing with the Swift project, and plans for initial DAS operations. This issue provides an update on the status of integration and test activities at the White Sands Complex (WSC), System Acceptance Test (SAT) activities, and initial DAS operations scheduled for July 2003.

DAS will expand TDRS Multiple Access (MA) return service capabilities by adding new receivers, monitoring tools, TCP/IP telemetry capabilities, and limited CCSDS data processing and distribution capabilities via the NISN IONet. ITT Industries (the AES division in Reston, Virginia) built the DAS using a variety of COTS hardware and software with customized programs tying all the various pieces together. The Consolidated Space Operations

(continued on page 22)

(continued from page 21)

Contract (CSOC) is providing systems engineering support at both GSFC and the WSC.

The operational DAS is currently in the late integration and test phase at WSC. The DAS team completed an early WSC Testbed capability to support premission activities with the Swift Project in April 2003. We conducted a formal Qualification Test Readiness Review (TRR) on April 1, 2003, at GSFC, and performed formal qualification testing at the contractor's facility in Reston from April 4 to April 11, 2003. A pre-ship review was held on April 29, 2003, and the system began shipment to WSC on May 5, 2003.

The team completed DAS operational installation and test at the Second TDRSS Ground Terminal (STGT), White Sands Ground Terminal (WSGT), and Guam Remote Ground Terminal (GRGT) on May 30. Shortly thereafter, preliminary System Acceptance Test (SAT) activities began. SAT was tentatively scheduled for the second week of June, with Initial Operations Capability (IOC) scheduled for July 15, 2003.

The DAS system has overcome many system developmental and installation hurdles along the way to its current state. DAS activity has shifted from the Reston, Virginia location where DAS was developed to the White Sands, New Mexico location where it will operate as part of the SN. Engineers have temporarily relocated to New Mexico to insure quality installation and testing of the DAS system. In conjunction with the on-site engineers at WSC, additional members of the DAS team are busily preparing the DAS for its initial operational state.

The team plans to compile an IOC-to-FOC (Full Operational Capability) timeframe capabilities list. During this timeframe, the DAS system will be available for customer premission testing activities and some other operational services; however, final integration and test activities will take precedence. Between IOC in July and FOC in September 2003, the DAS team will be "working off" numerous discrepancy reports designed to bring the system up to a full operational state.

In preparation for operations, we continue to test the DAS interface to the Space Network Web Services Interface (SWSI)—which will be used as the customer interface to DAS. DAS capabilities within SWSI will also become operational in 2003, and thus DAS-SWSI interface testing will be ongoing throughout the IOC-to-FOC time period

The DAS Website at *http://nmsp.gsfc.nasa.gov/das/* provides the history and goals for the project as well as DAS documentation such as the Test Readiness Review updates, the Operations and Maintenance Manual, DAS ground rules that describe how customers can execute services, and the latest DAS schedule. The website also contains useful links to sites such as the SWSI home page.

Potential future DAS customers include Aqua, Swift, Aura, LDBP, C/NOFS, and GPM. Swift, LDBP, and C/NOFS have all expressed interest in premission testing with the DAS system in the latter part of 2003, and we are tracking the DAS schedule to accommodate these activities when possible.

By Denise Gilliland/ITT

For additional information, please contact Tom Gitlin/Code 452 via email (Thomas.A.Gitlin@nasa.gov).

Mark Lorenz, DAS I&T Manager, at a DAS Console

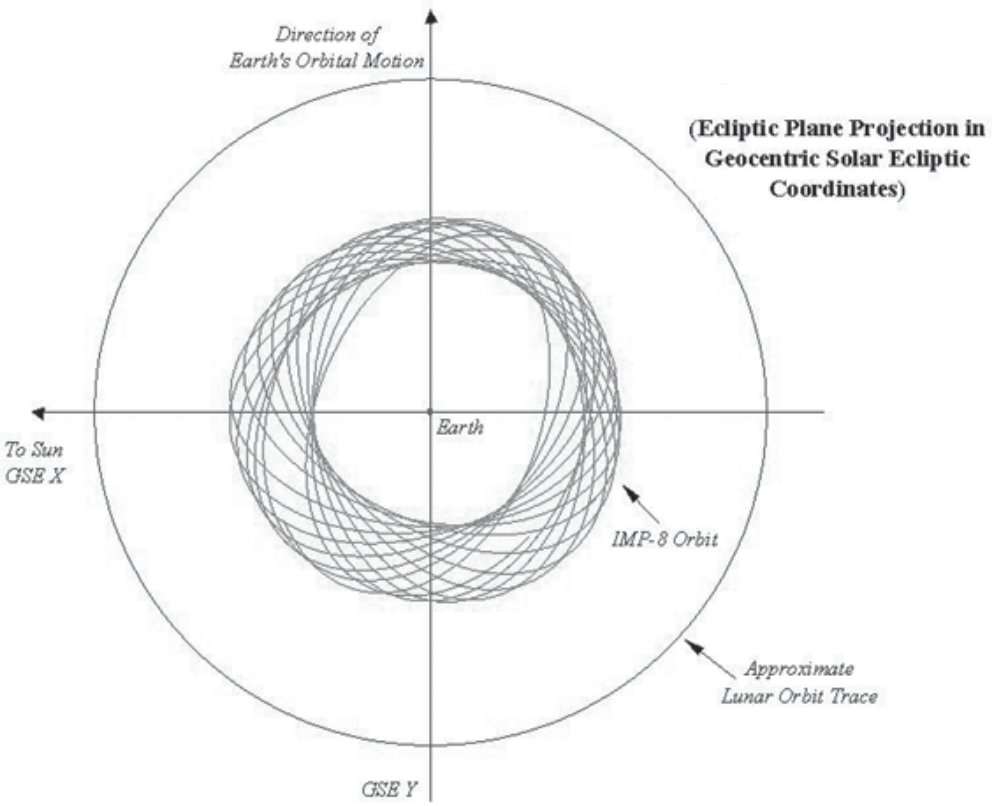
DAS Equipment Racks

Where (Exactly) Is IMP-8?

The IMP-8 spacecraft, launched on October 26, 1973, was the last mission in a long series of Interplanetary Monitoring Platforms (IMPs) that began in the early 1960s. IMP-8 is in a 12-day orbit with dimensions of 30 x 40 Earth radii—about halfway between Earth and the Moon. The instruments on board IMP-8 have studied the conditions and dynamics of the solar wind and its effects on Earth's magnetosphere as well as the acceleration and propagation of solar energetic particles, interplanetary shock particles, and galactic cosmic rays. While not all of its instruments are currently operational, IMP-8 still plays a vital supporting role in providing baseline measurements for the Ulysses and Voyager missions' study of the Sun and heliosphere.

Due to spacecraft hardware failure, no radiometric tracking of IMP-8 has been possible since the late 1970s. For almost 20 years, IMP-8 operations and science processing have relied upon a predictive ephemeris based on the last estimation of the orbit from tracking data. By the late 1990s, this ephemeris had begun to deviate substantially from reality, as evidenced by errors in predicted Earth and Moon shadows and antenna look angles. NORAD located the spacecraft in May 1998, but did not provide sufficient observational points for use in computing an improved ephemeris.

At the GSFC Flight Dynamics Facility (FDF), Heather Franz of CSC performed extensive analysis of historical IMP-8 shadow data to produce a more accurate orbit model. While this model produced an ephemeris clearly superior to the previously operational one, additional optical tracking data was required to predict the future orbit with confidence. Dr. Joseph H. King, the IMP-8 Project Scientist, sought orbit observation help from NORAD, the Lincoln Lab of MIT, and the University of Arizona's LPL visual observation team, but none of these groups were successful in their attempts to track the spacecraft.



IMP-8's orbit for April-October 2003, as predicted by GSFC's Flight Dynamics Facility

While surveying the night sky for near-Earth objects in February 2003, European astronomers tracked an unidentified object that appeared to be in geocentric orbit. Suspecting that this might actually be a man-made rather than natural satellite, Guy Hurst of the British Astronomical Association contacted the IMP-8 project. Comparisons between the astronomical observations and FDF's current ephemeris confirmed that this object was almost certainly IMP-8. Ms. Franz requested that the astronomers obtain further observations of the spacecraft, if possible, for use in computing a more accurate orbit model. Since February, the astronomers—Peter Birtwhistle in the UK and Reiner Stoss in Germany—have graciously provided additional data during subsequent orbit passes.

Since IMP-8 is only visible to optical telescopes for a couple of nights during each 12-day

(continued on page 24)

(continued from page 23)

orbit, significant improvements to the ephemeris accuracy will require observations taken over several months. To supplement the data provided by the astronomical community, the IMP-8 project has recently requested optical tracking assistance from NORAD. With enough observational data, FDF hopes to be able to compute a new IMP-8 ephemeris that will improve operations by producing better shadow predictions and antenna look angles and provide scientists with more accurate data for the past and future orbit.

By Heather Franz/CSC

For more information about this topic, please contact the author via email (hfranz@csc.com).

FDF Pushes the Limits

For the first time, the Flight Dynamics Facility (FDF) has provided prelaunch analysis and launch support for a ballistic trajectory mission!

On March 12, 2003, the mission lifted off from Vandenburg Air Force Base in California. It had a suborbital trajectory, impacting near Kwajalein in the Marshall Islands after a 26-minute flight. The objective of this mission was to use NASA's Space Network to collect data from the vehicle during flight using a CMC Electronics Cincinnati T-714 TDRSS transmitter.

Flight dynamics support of this mission was particularly challenging because the actual trajectory was classified and could not be used. Instead, the FDF utilized a representative trajectory and requested error ranges during critical flight times. Rigorous prelaunch analysis proved that the representative trajectory would be sufficiently accurate to meet acquisition data requirements.

In addition, the FDF's analyses showed that Type 8 (stationary) vectors with velocity would provide the best acquisition data support. Particularly interesting is that the entire trajectory could be supported using only five vectors, two of which were an astonishing 22 minutes apart! This is the longest span between Type 8 vectors ever used for Space Network launch or landing support. Minimizing the number of required vectors simplifies support and reduces potential errors.

During launch, the FDF was able to confirm that this long-gap acquisition plan resulted in excellent TDRS pointing. The customer was delighted, and the FDF looks forward to supporting additional similar missions in the future.

By Holly L. Offerman/FDF

For additional information, please contact the author via telephone (301-286-2197) or email (holly.offerman@gsfc.nasa.gov).

Learn more about GSFC's ***Flight Dynamics Facility*** *and the services and products it provides to the NASA community by visiting the FDF web site at:*

http://fdf.gsfc.nasa.gov/

CODE 453

Ground Network Project

Ka-Band Transition Project Demonstrates Ground Terminal Capabilities

In early 2000, NASA initiated the Ka-Band Transition Product (KaTP) to design and develop the necessary network infrastructure for demonstrating interoperable Space Network (SN) and Ground Network (GN) Ka-band data services. The project included development of a demonstration Ka-Band Ground Terminal at the Wallops Flight Facility (WFF). In recent months, the Ka-TP team has achieved significant progress and major successes on this portion of the project.

The KaTP team completed Ka-Band Ground Terminal hardware and software integration and system test activities in preparation for the high data rate bit error rate (BER) demonstrations and Ka-band Antenna Autotrack demonstrations that were performed in May 2003 and February 2003, respectively. Considerable planning and coordination were required to prepare for these demonstrations, including the development of detailed demonstrations plans and procedures.

During the BER demonstrations, the KaTP team members successfully verified 300 Mbps and 450 Mbps Staggered Quadrature Phase Shift Keying (SQPSK) uncoded direct links (end-to-end tests) by using a Ka-band signal source on a boresite tower located near the ground terminal at WFF. Figure 1 depicts the end-to-end link test configuration. Also, the KaTP team members successfully

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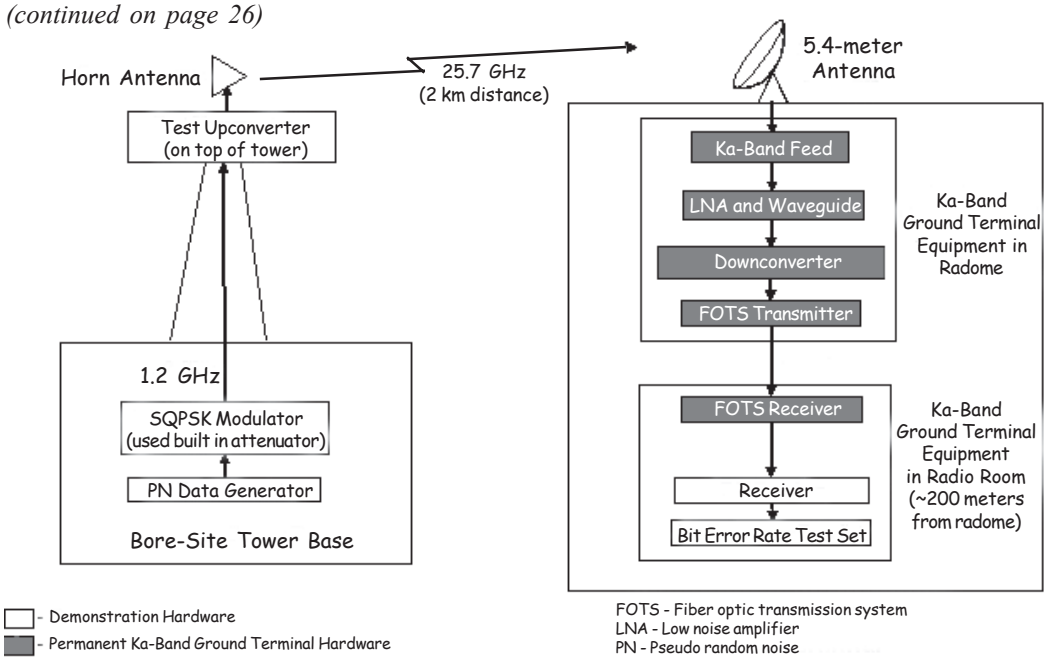

Figure 1. Ka-Band BER Demonstration End-To-End Test Configuration

(continued from page 25)

demonstrated uncoded 600 Mbps links using SQPSK with a medium loop test, depicted in Figure 2. A high data rate test modulator and receiver (600 Mbps, SQPSK) were procured for the BER demonstrations. The KaTP team plans to demonstrate 600 Mbps links with the boresite tower in August 2003.

The BER demonstrations also included back-to-back loop tests as Figure 2 depicts. During the tests, Eb/No versus BER data were collected to determine implementation loss at various BER points. By building up the test configurations in stages to reach the final end-to-end test configuration, the team could assess the effects of subsystem distortions on the end-to-end link by comparing the implementation loss observed during the various tests.

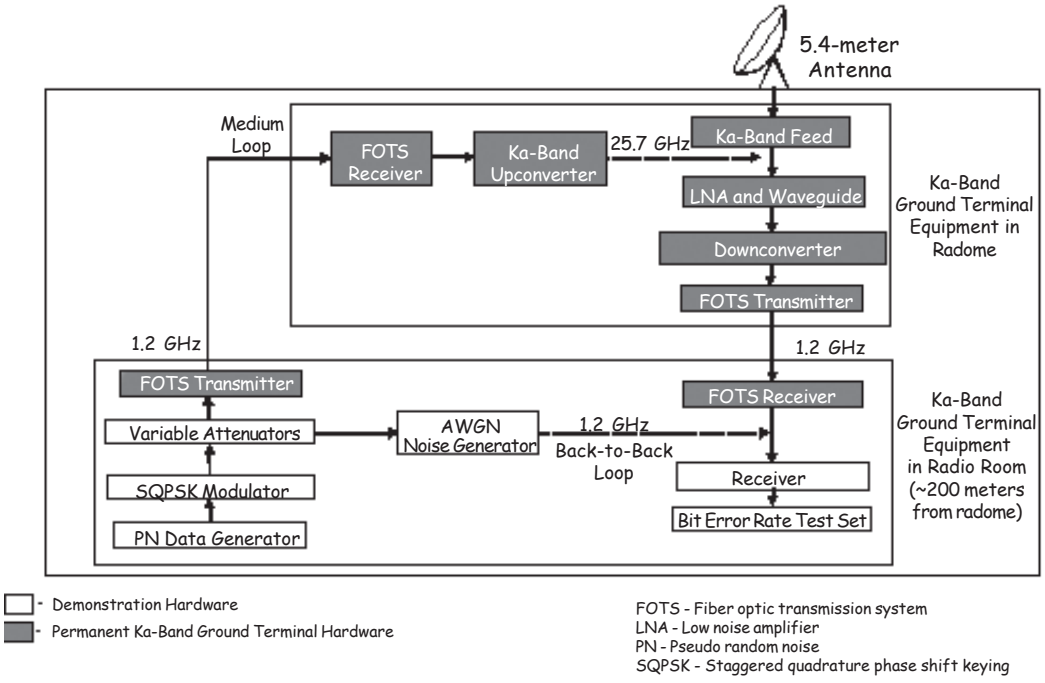

Figure 2. Ka-Band BER Demonstration Loop Back Test Configurations

Bit Error Rate	300 Mbps, Uncoded Implementation Loss (End-to-End)	450 Mbps, Uncoded Implementation Loss (End-to-End)	600 Mbps, Uncoded Implementation Loss (Medium Loop)
1×10^{-5}	3.7	4.7 dB	4.4 dB
1×10^{-7}	4.3	5.8 dB	7.5 dB

Table 1. Ka-Band Ground Terminal BER Demonstration Results

The BER demonstration results indicated an end-to-end 450 Mbps implementation loss of 4.7 dB at a 10^{-5} BER and a medium loop 600 Mbps implementation loss of 4.4 dB at a 10^{-5} BER. Table 1 summarizes the results for the 300 Mbps, 450 Mbps, and 600 Mbps tests. The Ka-Band Ground Terminal can now be used as a test bed to demonstrate Ka-band technologies.

The KaTP team also successfully demonstrated the Ka-band antenna autotrack capabilities of the Ka-Band Ground Terminal by using a Langley Research Center (LaRC) UH-1 helicopter as the moving Ka-band source. A helicopter was required because a Ka-band orbiting spacecraft was not available for the demonstration. The KaTP team constructed a customized 19" rack for the helicopter. The rack included S-band and Ka-band modulation and RF sources. The team also mounted Ka-band and S-band antennas on the helicopter. Figure 3 (at right) depicts the test configuration for the antenna autotrack demonstrations, while Table 2 (at right) summarizes the test events.

The helicopter flew a four-mile radius circular pattern during the demonstration. The Ka-band ground terminal initially acquired the helicopter using S-band. Then, after successfully tracking using S-band for several seconds, the Ka-band autotrack was selected by hand. The Ka-band

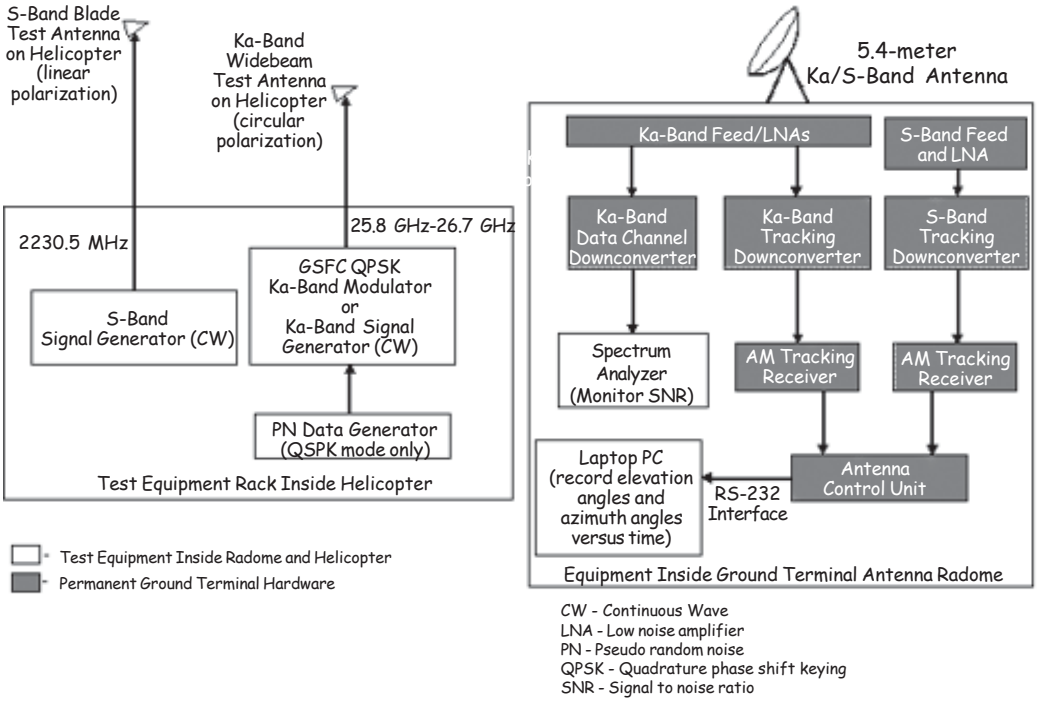

Figure 3. Ka-Band Antenna Autotrack Demonstration Test Configuration

Test Event	Frequency	Modulation	Polarization	SNR (12 MHz bandwidth)	Helicopter Altitude
1	25.8 GHz	CW	RHCP	15 dB	About 6000 ft altitude
2	26.5 GHz	QPSK (150 Mbps)	RHCP	10 dB	Altitude varied between 900 ft and 6000 ft
3	26.7 GHz	CW	RHCP	16 dB	About 2500 ft altitude
4	26.7 GHz	CW	LHCP	20 dB	About 2500 ft altitude

Table 2. Ka-Band Ground Terminal Antenna Autotrack Demonstration Test Events

signal-to-noise ratio was recorded at the ground terminal. After successful Ka-band lock occurred, the Ka-band Ground Terminal did not drop Ka-Band autotrack until it was deselected by the operator.

Look for additional information on the Ka-Band Ground Terminal high data rate testing in future publications of *The Integrator*.

By Mark Burns/ITT Industries and David T Miller/ITT Industries

For further information contact Yen Wong (301-286-7446) or Steve Bundick (757-824-1424)

NASA Provides Suborbital Support to Diverse Customer Community

The 2003 calendar year is proving to be a busy one for NASA's suborbital support community. Based at the Wallops Flight Facility in Wallops, VA, this organization is part of GSFC's Ground Network Project (Code 453) and primarily provides Tracking, Data, Acquisition, and Communications (TDAC) services to suborbital customers. Various TDAC support is also supplied during launch of certain Earth-orbiting vehicles, to on-orbit satellites, and to the Shuttle.

(continued on page 28)

(continued from page 27)

The Range Safety Command Van (l) and the additional Mobile Radar #8 (r) that supported the Conde Mission at Poker Flat Research Range

Inside view of the Range Safety Command Van

During the first half of 2003, the GN supported a series of seven sounding rockets from Poker Flats, Alaska, using mobile range equipment. Sponsored by various universities, these science missions explored the conditions in Earth's aurora. Typically, such missions require deployment of one radar system and two telemetry systems. One of these rockets, the Conde mission, necessitated the use of two radar systems, two telemetry systems, and a range safety and command system. Support of this campaign was especially demanding since the GN had just employed these same mobile systems to support a launch from Svalbard, Norway the previous December. It was quite a challenge to quickly transport and configure the equipment and personnel required for the Alaska campaign!

This spring, the GN has been supporting a number of interesting missions for the Department of Defense (DoD). We are assisting the Navy in testing its new and upgraded onboard weapon systems. After the systems are installed on Naval vessels, the ships sail south past WFF. NASA WFF launches several Naval target vehicles (including BQM and Vandal rockets) near the ships as they pass by, and the Navy assesses the performance of the new weapons by shooting the target vehicles down. The GN provides telemetry, tracking, and communications support for these exercises.

Later this year, we will support the Navy in its Combat Ship Systems Qualification Test (CSSQT) program. This series of tests is similar to those described above but will test both air and sea capabilities utilizing multiple targets. Unmanned Aerial Vehicles (UAVs) will be added to the list of target vehicles used, and we will support the launch and flight of more than six targets in the complex testing scenario.

The GN also provided support to the U.S. Army this year. During the Aberdeen Gun Testing Program, we provided TDAC services for several missions consisting of rocket-assisted projectiles. The purpose of these tests was to demonstrate the systems' successful launch, survival, operation, and performance. For the Army Space and Missile Defense Command's Red Dog mission, we supported two rocket launches from WFF—one in May and one in June. Each rocket carried four major payloads from which RF and infrared data were collected using air- and ground-based sensors. Code 453 provided the TDAC services for this mission while Code 800 provided launch services at WFF.

During the month of June 2003, the GN provided TDAC support to eight sounding rockets, one of which was a reimbursable mission. The remaining seven were NASA missions including four geospace science missions, two student-sponsored missions, and a test/demonstration flight.

In addition, we are preparing to support a major campaign using mobile systems on Kwajalein Island in the Pacific in June 2004. This campaign will involve 14 rockets, all of which are science missions. Prelaunch testing is a primary component of the GN support to be provided. This endeavor will require us to ship mobile telemetry readout equipment (housed in one or two 40-foot trailers) to the island for science payload assembly and setup.

The GN is also making preparations to support the DoD's Defense Advanced Research Projects Agency (DARPA) with tests of its SCRAMJET mission during September 2003-August 2004. During these tests, the GN will provide TDAC services for DARPA as it launches at least five vehicles to demonstrate new technologies.

For further information on GN suborbital support, please contact Steve Currier via email (stephen.f.currier@nasa.gov) or telephone (757-824-1646).

A Black Brant XII vehicle launches from Wallops Flight Facility. This type of vehicle was used for the Army Space and Missile Defense Command Red Dog Mission in late May and early June.

Two rockets in styrofoam boxes on the rail at Poker Flat Research Range. Heat is pumped in through the orange tubes to keep the rocket motors and payloads from freezing. The rockets launch right through the stryofoam boxes.

Hanging payload on an Orion rocket motor on the rail at Poker Flat Research Range

TDRS Project

NASA Accepts TDRS-J

On May 29, 2003, NASA accepted the TDRS-J Spacecraft, which was launched on December 4, 2002. Shortly after TDRS-J reached its geosynchronous orbit testing location, engineers successfully conducted bus on-orbit tests on the spacecraft. In late December 2002, however, TDRS-J experienced an unplanned event when the Spacecraft Control Processor 1 (SCP1) toggled to the redundant processor. Payload on-orbit testing was delayed to allow for troubleshooting and an investigation of this event. Following several tests and analyses, the SCP1 was placed in control of the spacecraft on February 23, 2003 and continues to function nominally without any anomalous signatures.

Payload on-orbit testing resumed on February 25 and was successfully completed on April 11, 2003. A final review of the SCP 1 investigation was held on May 15. The On-Orbit Test Review of TDRS-J occurred on May 20 and NASA accepted the satellite on May 29, 2003. With this event, the White Sands Complex Maintenance and Operations contractor assumed control and day-to-day responsibility for TDRS-J, now known as TDRS-10, on behalf of the Space Network Project. The satellite will remain at its test location of 150º West longitude in a storage mode until it is needed for Space Network customer services operations.

For more information on the TDRS program, please visit the Code 454 web site at http://tdrs.gsfc.nasa.gov/tdrsproject/.

The Integrator

is located on the MSP web site at
http://msp.gsfc.nasa.gov/integrator/.

Previous issues of this publication are also available on line in *The Integrator* Archive.

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